The determinants of country corruption. Measurement errors, unobserved heterogeneity and individual choice, an empirical application with Finite Mixture Models

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Abstract

Corruption in public offices is found to be the reflection of country-specific features, however, the exact magnitude and the statistical significance of its determinants effect has not yet been identified. The paper aims to propose an estimation method to measure the impact of country fundamentals on corruption, showing that covariates could have differently affect the extension of corruption across countries. We introduce a model able to take into account different factors affecting the incentive to ask or to be asked for a bribe, coherently with the use of the Corruption Perception Index. Discordant results achieved in literature may be explained by omitted hidden factors affecting the agents' decision process. Moreover, assuming homogeneous covariates effect may lead to unreliable conclusions because the country-specific environment is not accounted for. We consider a Finite Mixture Model with concomitant variables to 129 countries from 1995 to 2006, accounting for the impact of the initial conditions in the socio-economic structure on the corruption patterns. Our findings confirm the hypothesis of the decision process of accepting or asking for a bribe varies with specific country fundamental features.

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1 Introduction

The paper aims to test the effects of country-specific social and economic environment on corruption, tacking into account the unobserved heterogeneity and the error in variable biases. Corruption of a public officer is a phenomenon hard to define and to measure in terms of some causal-effect models. In fact, the decision to be corrupt (or corrupter) could be affected by country's specific features - such as the legal and political structure, the socio-economic environment and the cultural or religious settings (see among others, Svensson, 2005) - as well as by individual specific preferences. On the other hand, the corruption level within countries could affect the legal and political system, as well as the economic environment. This causal chain generates a sort of feedback effects between the determinants of corruption and its effects, at least at macro level, making hard the provision of a correct estimable model.
The "measurement" difficulties are confirmed by the extreme variability of the empirical and

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theoretical results achieved in literature. In fact, there is not yet a consensus on the impact of country-specific features on corruption dynamic (see among others, Friedman et al. 2000, La Porta et al. 1999, Treisman, 2000; Acemoglu, Daron, and Verdier, 2000 and so on), as well as there is not an unique interpretation on how the political and economic environment interacts with the extent of corrupt activities (Braun and Di Tella, 2004; Paldam, 2000; Fréchette, 2006; Husted, 1999; and so on). The discordant results - concerning sign, magnitude and statistical significance of the above evidenced macro or micro determinants - may reflect a miss-specification of the relationships underlying the phenomenon.

Moreover, the country invariant assumption on the corruption determinants seems to be unrealistic, since it assumes the existence of the same effect on corruption in environments with different country-specific fundamentals (quality of institutions, empowerment rights, economic growth, public expenditure and so on).

Furthermore, as Banerjee et al. (2012) point out, corruption is a "per se" hidden action involving individual decision process. The provision of a comprehensive definition of corruption, and consequently of a common accepted index, could be one of the source of the measurement errors characterizing corruption analysis. In fact, the standard definition of corruption (the misuse of public office for private gain, World Bank, 1997 and UNDP, 1999) does not completely describe it, because it does not explicit the private agent's behavior, as well as the criminal nature of the phenomenon. On the other hand, a definition that involves the criminal nature of the phenomenon could generate distorted empirical results, since an estimable model for corruption should include the recorded number of offenses (i.e. the number of corrupt act that a person commits) as dependent variable. As it is better explained in Section 3 and 5, this generates empirical problems due to ambiguous correlation between country-specific fundamentals (government expenditure, judiciary system and so on) and number of corrupt acts recorded in a certain country in a certain time window (see among Lamsbdorrt, 1999)[1]. On the other hand, the use of indexes on corruption could generate empirical distortion, due to the difficulty of capturing the effective corruption level within countries (see among others Olken, 2007, and Donchev and Ujhelyi, 2007)[2].

Moreover, we believe that the use of indexes, as like as the here used Corruption Perception Index, allows us to capture at least the likelihood of having corrupt agents among countries, according to how the public sector is seen to be, and, at the same time, to define corruption in a more flexible way. In fact, we assume in the following that "corruption occurs at the interface of private and public sector"[3] (Ackerman, 1997), as result of individual rational decision process based on the comparison of connected perceived expected costs and perceived expected benefits. In other words, we argue that the corrupt acts are undertaken according to how agents perceive costs and benefits of the action itself, coherently with a perceived measure of corruption. Thus, a suitable model is obtained once it includes individual tastes and preferences, sense of the justice, and attitude towards risk in committing illegal acts, that collectively determine or cause the agent's choice. The omission of these variables, due to their unobservable and/or no-measurable nature, could lead to biased estimation.

[1] Lamsbsdorrt (1999)points out that the relationship between government expenditure and corruption could be positive or negative depending from the use of public founds. An improvement in the judiciary system's efficiency, due to the high amount of public funding directed to the judiciary system itself could reduce corruption perception. In addition, the country-specific nature of the national law makes the estimations not comparable among countries.

[2] Both the paper empirically test the hypothesis that beliefs about corruption of the respondents may not reflect the real level of corruption and then the statistical tests are biased.

[3] In this way, it is clear that we drop out the possible corrupt behaviors between public officials (to gain position) or between private firms (to obtain procurement)

In our empirical analysis, we assume that the misspecification derives from the country specific unobserved heterogeneity and, following Aitkin (1999), we consider it directly inside the empirical model. In other words, posing a random coefficient for some (or all) variables in the empirical design, a latent trait enters the model to adjust the parameters' estimation for the unobserved heterogeneity, due to the differences between the country economical, political and social environments. Indeed, the finite mixture model, applied here to an unbalanced panel of 129 countries from 1995 to 2006, allows for dividing the entire sample in groups sharing the same effects of the unobserved (latent) variables. This means that groups are formed by countries having the same socio-economic structure, given the observed and unobserved covariates. Moreover, to partially adjust the estimation for the feedback effect between the corruption index and the country-specific conditions, we estimate prior probabilities conditioning on initial measures (at year 1995) of per capita GDP, fiscal rate and schooling. The concomitant finite mixture model applied here allows for conditioning these probabilities on the initial social and economical structure of the country itself.
To conclude, the estimation procedure that we adopt in this paper allows us to deal with two challenges: at empirical level, it provides an approach to mitigate three statistical problems related with the country-specific characteristics: omitted variable, country-specific heterogeneity and error-in-variables. In addition, it could solve the literature debate about the effect of the determinants of corruption, by showing that the controversial empirical results, illustrated in Section 2, could be the reflection of the omission of hidden factors underlying the agents' decision process. Our findings confirm that the decision process of accepting or asking for a bribe is influenced by political, economic and social country-specific characteristics, on the basis of the environments, providing evidence for unobserved heterogeneity. The paper is divided into six sections (including introduction and conclusions). The second section briefly reviews the existence literature about corruption, highlighting the theoretical and empirical debate. The third section underlying the empirical model, that is illustrates in the fourth section. The fifth section presents the database used in the paper. The sixth section presents the results of the mixture approach, comparing them with those of a homogeneous parameter benchmark. This section identifies clusters of countries after conditioning on the initial level of GDP per capita, the tax burden and the education level within countries. The seventh section concludes.

2 Literature review

Since 1994, literature about corruption has expanded rapidly following the provision, among others, of the Corruption Perception Index and the Control of Corruption (respectively provided by the Transparency Index and the World Bank). This allows the researchers to empirically test the interaction between corruption and political, social and economic factors. Despite the availability of quantitative data on the phenomenon, its link with country fundamentals is debatable. As stressed in Table 1, empirical and theoretical findings agree that corruption interplays with political, social and economic environments, but they disagree on magnitude, sign and statistically significant of the relation.

Insert Table 1 about here

GDP (both in terms of growth rate and wealth per capita) is found and thought to be one of the main economic variable affecting the level of corruption within countries, even if its impact is debatable. Despite it is found to reduce economic growth, by lowering private investments and Foreign Direct Investment (FDI) and distorting public services provision (Mauro, 1995; Anderson and Marcouiller, 2002; Wei, 1997), Paldam (2002) stresses that the correct causality relation is the reverse. In fact, in a transition model, he finds that corruption is a characteristic of poor and middle income countries, that disappears when they go through the grand transition to become high-income countries. Furthermore, many economists (Husted, 1999; Serra, 2004; Ata and Arvas, 2011; Svensonn, 2005) empirically test this result, by positively relating the level of GDP per capita and the growth rate of GDP with corruption. As theoretical explanation, they argue that an high level of GDP is associated with an high amount of Government resources, that can in turn be used in fighting corruption. In addition, rich and developed countries create a demand for institutional change and good government, that decrease officials' corrupt activities (Svensonn, 2005). Braun and Di Tella (2004) and Fréchette (2006), by using panel data, deviate from this commonly accepted result, by noticing that, because corruption has a pro-cyclical nature, 'moral standard are lowered during booms, as greed becomes the dominant force for economic decisions' (Braun and Di Tella, 2004, p.93). As stressed in Table (1), the contrasting results concern mainly the impact of the degree of intervention of the State in the economics and political environment (i.e., Government intervention and size) and the effect of the monitoring activity on corruption in the public sector (i.e., the extent of competition). Regarding to the latter, despite empirical estimation proves that competition, openness to trade and FDI are commonly linked to a low level of corruption (see among others Ades and Di Tella, 1996; 1999[4], and Robertson and Watson, 2004[5]), theoretical results do not lead to a unique conclusion. Lambsdorff (1999) notices that an high level of competition lowers the rents of economic activities and the motive of public office to seize parts of these rents. Ades and Di Tella (1999) highlight that the competitive pressure does not leave to the firms excess profit to pay bribes. On the other hand, Bliss and Di Tella (1997) develop a model in which the official, by inducing exit from the market, create the excess profit from which pay a bribe. Despite the impact of competition among firms seems to have not a unique interpretation, it is commonly accepted that competition among public officials, by decreasing their monopoly power, reduces the propensity to accept a bribe (Ackerman, 1997). In fact, as Ackerman points out, the structural characteristics of the Government affect the demand for corrupted service. In turn, these factors together with the political features (including democracy, decentralization and unitarism) determine the quality of the Institutions.

Nonetheless, it is commonly accepted that a low level of corruption is associated with Institutions able to promote social cohesion, protect property rights as well as freedom of belief and religion, and ensure compliance with the law. Researchers directly measure the Institution quality by looking at the risk of expropriation within countries. Despite the lack of quantitative data hinders estimations, they agree that the lower the risk of expropriation (the higher the quality of institution), the lower the propensity to be asked for a bribe (Mocan, 2004).

As hinted before, the impact on corruption of the size of the State has not been reached a consensus in literature. Indeed, empirical estimation performed on the effect of the public expenditure in final goods as share of GDP - as a proxy for the Government size - leads to contrasting results. Bilger and Goel (2009), by using a quantile regression, and Adserá et al.

[4]Ades and Di Tella (1999) by using country's openness as an indicator of competition, empirically prove that economic competition decreases the extent of corruption; they also prove that the entrance of foreign investments corresponds to import competition and to reduce the rents for domestic firms and thus the rewards from corrupt activities.

[5]Robertson and Watson (2004) analyze the rate of FDI's inflow. After controlling for cultural variables (gender, religion and so on), they prove that the more rapid the increase or the decrease in FDI into a country, the higher the perceived level of corruption.

(2003), find a negative relation between government size and corruption. On the other hand, starting from the idea that the State intervention and public spending give rise to rent-seeking, Goel and Nelson (1998) and Fisman and Gatti (2002), by using the number of public officials convicted for abuse in public office in USA, find a strong positive influence of government and local expenditure on corruption. The impact of the role of the State on corrupt phenomenon is debatable, even by looking at the Government intervention in the form of regulation and taxation. Since the intervention of the State in the market could generate partner advantages over rival, Treisman (2000) proves that the two variable are positively related [6]. Conversely, Friedman et al, (2000) conclude that an high degree of tax rate is associated with less unofficial activities, because of the stronger legal environment[7] Despite democracy is thought to reduce the diffusion and the existence of the phenomenon, empirical findings do not completely confirm this theoretical result. Treisman (2000), among others, shows that only after 40 years, an uninterrupted democracy has a decreasing effect on the level of corruption, in terms of risk of being a victim of bribery. Moreover, democratic elections could create room for corruption. As Kunicova and Rose-Ackerman (2005) and Persson and Tabellini (2003) argue, party lists could represent an aspect of the democratic election that generates corruption; in fact, in their view, if there is not a direct link between voters and politicians, the latter agents could be less accountable by citizens.

Literature agrees about the relation between corruption and others government specific characteristics, as the legal origin of the country and the law system. In fact, British legal origin, putting the attention on individual's right (private and property), is found to face a low level of corruption (David and Brierley, 1978, Finer, 1997, La Porta et al., 1998). French or Scandinavian legal origin, characterized by a greater attention to the power of the State, face an high level of corruption (Mocan, 2004). Similarly, whereas a common law system, developed in defense of property right and parliamentarianism, is found to lower corruption, the civil law system, concentrated on the sovereignty of the State, is found to increase corruption (David and Brierly, 1985; La Porta et al., 1999; Treisman, 2000). Gerring and Thacker (2004) confirm these results finding that parliamentarianism and unitarianism, by centralizing the political power and reducing the number of potential veto points, decrease corruption level.

Since corruption is a human activity, many economists show how cultural variables, as religion (e.g. La Porta et al., 1997; Treisman, 2000)[8] and education, can affect the propensity to behave illicitly. Regarding to the latter, it is worth noting that the stock of human capital, by interacting with institutional factor and by increasing citizens' monitoring ability, could play an important role in discouraging officials' corrupt activities. In fact, educated citizens have tools both to distinguish between corrupt and honest politicians behavior (Eicher, Penalosa and Ypersele, 2007) and to punish government abuses (Glaeser and Saks, 2006), as well as, once recruited, to improve efficiency of courts and Institutions (Svensonn, 2005); as a consequences, educated citizens discourages the extent of corruption, by increasing the institution ability in frightening corruption.

Nevertheless, despite the consensus reached about the relation between cultural variables and

[6] Treisman (2000) demonstrates that the State intervention is associated in 1996 with higher corruption, even if this is not significant either in the 1997 or the 1998 data.

[7] Friedman et al, (2000) also argued that the results depend on how the tax system is administered.

[8] Researchers agree that hierarchical religions are positively related to the corruption level (e.g. La Porta et al., 1997). More into detail, Treisman (2000) finds that the larger the diffusion of the Protestantism in a country's population as of 1980, the lower the corruption perceived to be. In fact, according to him, Protestantism, as a traditional religion, is characterized by an independent church that can play a role in monitoring the state officials' abuse, conversing to hierarchies religion, characterized by interconnected state and church

corruption, it is worth noting that, according to our knowledge, literature in this field does not take into account that the choice of undertaking a corrupt activity, as result of individual decision process, is influenced by unobservable and/or no-measurable factors, as the private sense of the justice, and the attitude toward risk. In fact, we believe that the lack of these hidden variables makes literature about corruption characterized by the contrasting results showed in this section and summarized in Table 1.

3 The definition of corruption

Following the criminal law and the economics of crime framework[9], we define corruption as the outcome of rational choices undertaken by a corrupter (private) agent and a public office (Ackerman, 1997). In this way we limit our model in the assumption that the phenomenon results only from the interplay between the private and the public agent, by dropping out the possibility of capturing criminal interaction among private firms (i.e., to obtain procurement) or among public office (i.e., to obtain position).

The private (corrupter) agent acts as a *demander* of corruption, by involving the abuse of public professional power position in order to obtain a legal or an illegal act, as well as an omission. The public (corrupt) agent, as a *supplier*, offers the misuse of his public power position to gain financial, material or not material benefits, such as bribe or other type of compensation.

Following the usual framework corruption activity C_{it} in country $i = (1, ..., n)$ at time $t = (1, ..., T)$ could be represented by a function involving the risk of punishment rp_{it} and the economic incentive ei_{it} characterizing each country in a certain time-window, such that:

$$C_{it} = f(rp_{it}, ei_{it}) \tag{1}$$

As rational agents, they maximize their utility function, by comparing the economic return from all the opportunities (i.e, bribe and non material reward) with the risk faced in committing the criminal act (i.e., the risk of being getting caught), given the private set of preferences. In other words, individuals accept or demand a bribe (or non material reward) if it promises the greatest economic return, on the basis of Government's capability in deterring and punishing, rp_{it} - the so-called *risk of punishment* (see among others, Becker, 1968) - as well as *economics incentives* given by the environment in undertaking a corrupt activity, ei_{it}, and individual tastes and preferences that underlying the subjective utility function. Despite the latter factors are powerful in explaining corruption from a theoretical point of view, they are generally hidden and/or no-measurable. Thus, in order to obtain a coherent and unbiased model about the determinant of corruption, we have to empirically deal with these omitted variables, by including in the model factors able to affect the subjective utility function, as the individual tastes and preferences, the propensity of committing illegal acts, the sense of the justice, as well as the attitude towards risk.

Furthermore, in order to estimate the determinants of corruption, we face two empirical problems that affects the dependent variable. Firstly, we requires the recorded number of offenses (i.e., number of corrupt act that a person commits) as a dependent variable (Ackerman, 1998).

[9]The criminal law definition of corruption is based on the interaction of an active (private agent) and passive (public office) corrupt agent. The former is the demander, the latter is the supplier of criminal behavior (Walle, 2010). We use the definition of Ackerman (1997): 'corruption occurs at the interface of the public and private sector'

As we discuss above, since the illicit and secretive nature of the phenomenon, it is not reasonable to use the number of person convicted or persecuted to perform the estimation. Secondly, even if the data were completely recorded, a cross country regression would be biased, because of the country-specific nature of the national law (i.e., the national law is different among countries, thus what is crime in a society may not be crime in another) and nothing assures that perception of corruption effectively matches that real. In order to avoid these problems, we test the impact of country-specific factors on corruption by using the perceived level within countries. Since the dependent variable measures the likelihood that a country is corrupted, by looking at how the public sector is seen to be, we have to reformulate the model as a sort of *perception* model, with the aim of capturing the determinants of the corruption perception, in spite of testing the impact of the risk of punishment on corruption.

The idea is that the perceived level of corruption reflects the private perception about the likelihood of being asked or asking for a bribe. We argue that these beliefs are formulated on the basis of the expected risk of being charged with criminal offenses, and the expected benefits for the *demander* and the *supplier* of undertaking corrupt behavior.

In other words we don't use the corruption perception index to conclude about the real level of corruption, but we use this index in terms of what is the perceived level of corruption in that country.

For this reason, the expected costs - the probability of being getting caught, and any disutility regarding immorality (McChesney, 2010) - as well as the expected benefits - bribe, or any type of compensation, and the possibility of avoiding bureaucratic system - are analyzed under the individual perspective.

The expected *risk of punishment* for corruption is determined by *macro* and *micro* level factors. As macro measure we consider the general model of crime, as the intervention of the State in the economic system in terms of size of the State[10], gs_{it}, accounting for the role of democracy, d_{it}, and the Government fractionalization, ps_{it}.

In order to have a comprehensive measure of the perceived capability of the State in increasing the likelihood of being getting caught[11], the perceived level of protection of civil and political rights, r_{it}, and the degree of independence of judiciary system, j_{it} enter the model as *micro* level factor. Thus, we rewrite the risk of punishment function as:

$$rp_{it} = f(r_{it}, gs_{it}, ps_{it}, d_{it}, j_{it}) \tag{2}$$

The idea is that the temptation of behaving illegally depends on the size and the role of the State - as *macro* measure - and on the private perception about the effective intervention of the State in case of non compliance with the law - as *micro* factor. In fact, it seems reasonable to believe that a country characterized by an independent judiciary system and an high degree of protection of civil and political rights is viewed by citizens as active in ensuring compliance with the law, as well as in procuring the necessary tools to the people to participate in checking and denouncing corruption in public office.

The expected returns are determined by the *economics incentive* given by the country-specific environment. Thus, the individual's gain depends on *direct* - bribe and any type of compensation - and *indirect* returns - the avoidance of the bureaucratic system. In other words, the expected benefit from corruption is given by the possible gain for the private agent of avoiding

[10] In order to measure the size of the Government we follow the economic literature (see among others Kotera, Okada and Samreth, 2012) by assuming that it can be approximate as the general government final consumption expenditures, as a share of GDP.

[11] In the economics of crime, the risk of punishment is estimated by using objective data, as the per capita police expenditure, on the deterrent effect that police presence may have on the criminal behavior.

the bureaucratic system, as well as of obtaining a reduction in the tax burden. In this way, the probability to ask for or accept a bribe is affected by the impact on the private agent's activity of the bureaucratic service b_{it}, accounting for the country-specific financial environment in terms of State intervention in financial services and openness, f_{it}, as well as openness to trade. In fact, as discussed in Section 2 (see among others, Ades and Di Tella, 1999) openness to trade [12] o_i, seems to affect corruption level within countries. More into details, following the economics literature, we believe that the international commercial activity could decrease the monopolistic rents enjoyed by bribe. Thus, openness to trade, as a proxy, enters the model. Summing up, the *economic incentives* may be modeled as follows:

$$ei_{it} = f(b_{it}, f_{it}, o_{it}) \qquad (3)$$

In the following we obtain the estimable model for the system in equations 1, 2 and 3. Furthermore we show also in which way the initial level of economic factors affects the results. In particular, as it is formalized in the following section, the initial level of education, $educ_{i,95}$, of the GDP per capita, $gdp_{i,95}$, as well as the tax burden, $t_{i,95}$, enter the model as concomitant variables, with the aim of controlling for socio-economics factors. In fact, we believe that these variables affect the *a priori* probability for each country of belonging to a certain cluster.
Summing up, by performing a finite mixture model with concomitant variables, we get the $\boldsymbol{\beta}$ parameter vector's estimation, that tell us the heterogeneous impact of the set of the covariates and concomitant variables on the corruption perception. In fact, as a results of the mixture we get the estimated number of clusters, say k, compatible with the data. Each group is characterized by homogeneous values of the estimated random effect. In addition, by using penalized likelihood criteria we identify locations of each observation. Thus, we obtain the prior probability for each country of belonging to cluster k, given the concomitant variable c and its parameter α. Furthermore, by getting the parameter α estimation[13], we identify whether the concomitant variable can affect the probability for each country of belonging to a certain cluster, with respect to the benchmark group (group 1). Furthermore, the (probability) clusters are obtained once the model has been fitted through the maximum likelihood estimator, in terms of fitted posterior probabilities of component membership of the data[14].

4 Empirical Model Specification

As evidenced in the introduction, the secretive and complex nature of corruption makes empirical estimation characterized by three statistical problems: the error-in-variables bias, the homogeneity assumption of the effects of the countries-specific determinants on corruption, and the omitted variable bias. In order to take into account these challenges in the estimation process, we apply a finite mixture model with concomitant variables. In this way, the parameters estimation are obtained as dependent on the different socio-economic environment characterizing each country $i = (1, ..., n)$. Indeed, by allowing for a latent variable to enter the estimation process, we could find unbiased and comprehensive estimators of corruption determinants. On the basis of the latent variable, the entire sample n is clustered in $k = (1, \ldots, K)$ subgroups. Furthermore, in order to capture the relationship between behavioral and socio-economics

[12] We use the typical trade openness measure that is the trade intensity, i.e., the sum of the share of imports and export dividing by the GDP.

[13] From a computational point of view, as stressed by Grünn and Leish (2008) and Dayton and Macready (1988) the concomitant variables are to be simultaneously estimated in the EM process.

[14] See among others Alfó et al. (2008) for computational detail

variable, the weights of the mixture (i.e., the group size) depend on concomitant variables, i.e. variables affecting the country probability of belonging to a specific cluster. Thus, we relax the assumption that the magnitude of the effects of the determinants are country invariant, allowing them to be distinct among groups in which countries are characterized by similar features. In fact, since in our framework countries' heterogeneity is due to unobserved (latent) differences between the country-specific fundamentals, it is more reasonable to assume that these factors have the same impact among countries characterized by similar feature, rather than among the entire sample. This motivates the need of clustering the population in sub-groups, in which the assumption of homogeneity holds.

Formally, let y_{it} the vector containing the realized conditionally independent and identically distributed random variables of the recorded value of the perceived level of corruption corresponding to the year $t = (1, \dots, T)$ measured for each country $i = (1, \dots, n)$ country in the sample. Let x_{it}^1 the set of country-specific covariates capturing the perception about the risk of punishment, such that $\mathrm{x}_{it}^1 = rp_{it}$, and x_{it}^2 the set of covariates capturing the economics incentive in undertaking a corrupt activity, such that $ei_{it} = \mathrm{x}_{it}^2$, as respectively described in equation (2) and (3).
Moreover, it is well known that when we estimate a model with possible omitted explanatory variables we could have bias in the estimated parameters and in their related significance.
Assuming a standard linear model, and letting $\boldsymbol{\beta} = \{\boldsymbol{\beta}^{\mathsf{T}}{}_0, \boldsymbol{\beta}^{\mathsf{T}}{}_1, \boldsymbol{\beta}^{\mathsf{T}}{}_2\}$ the parameters vector, the function in equation (1) can be empirically written as:

$$E(\mathrm{y}_i | \mathrm{x}_{it}^1, \mathrm{x}_{it}^2) = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1^{\mathsf{T}} \mathrm{x}_{it}^1 + \boldsymbol{\beta}_2^{\mathsf{T}} \mathrm{x}_{it}^2 \tag{4}$$

where x_{it}^1 stand for *risk of punishment*, and x_{it}^2 for *economics incentive*. Nevertheless, OLS based estimation of equation (4) could conduct to bias results since OLS assumes that on average the effects on y_{it} of the matrix x_{it}^1 and x_{it}^2 are homogeneous among countries (see among others, Durlauf et al., 2005). In other words, following this empirical process, parameters in $\boldsymbol{\beta}$ result to be equivalent in terms of sign and magnitude among different countries, even if they are characterized by different and/or omitted and no-measurable economics, social and institutional features. Thus, in order to simultaneously get unbiased and comprehensive estimators of the determinants of corruption, we have to deal with the omission of the explanatory variables, and the difference in terms of sign and magnitude of the parameters in $\boldsymbol{\beta}$.
In our empirical model, we assume that the parameters $\boldsymbol{\beta}$ are allowed to vary among countries. Let u_i denote the set of unobserved country-specific random factors, that accounts for country-specific heterogeneity and dependence among covariates. In this way, we obtain clusters from fitting $k = 1, \dots, K$ components mixture density (Frühwirth-Schnatter, 2006), on the basis of the conditional mixing proportion. Indeed, we believe that risk of punishment and economic incentives in undertaking a corrupt activity differently affect the level of corruption among countries, because of differences in culture, religion, legislation and so on. Since a finite mixture distribution[15] is a convex linear combination of the probability density function of each k components, weighted for the *a priori* probability for each observation $i = 1, \dots, n$ in

[15]More into detail, y_{it} is said to arise from a finite mixture distribution if the probability density function $p(\mathbf{y}_i)$ of this distribution takes the form of a mixture density for all $\mathrm{y} \in \mathrm{Y}$, and we can rewrite the distribution of the observed data $\mathbf{y}_i$ as follows:

$$p(\mathbf{y}_i) = \sum_{k=1}^{K} [\pi_k p_k(\mathbf{y}_i)]$$

where p_k are the component densities and π_k are the *prior probabilities* or the *mixing proportion* such that $\sum_{k=1}^{K} \pi_k = 1$ and $0 < \pi < 1$. See among others following Frühwirth-Schnatter (2006) for further detail time $t = 1, \ldots, T$ of belonging to a certain cluster $k = 1, \ldots, K$, we can rewrite equation in (4) as:

$$E(\mathrm{y}_i|\mathrm{x}_{it}^1, \mathrm{x}_{it}^2) = \boldsymbol{\beta}_{0i} + \boldsymbol{\beta}_{i1}^{\mathsf{T}}\mathrm{x}_{it}^1 + \boldsymbol{\beta}_{2i}^{\mathsf{T}}\mathrm{x}_{it}^2 \tag{5}$$

where $\boldsymbol{\beta}_{1i} = \beta_1 + u_i$ is the vector of coefficient associated to the perception about the risk of punishment, $\boldsymbol{\beta}_{2i} = \beta_2 + u_i$ the vector of parameters associated to the perception about the economics incentive, and the intercept term $\beta_{0i} = \beta_0 + u_i$ varies across countries in order to capture country-specific features. More into detail, we allow the existence of different latent factors u_i for each set of parameters. Following this empirical estimation procedure, $\boldsymbol{\beta}_{1i}$ and $\boldsymbol{\beta}_{2i}$ are deviations from the common shared effects measured by β_1 and β_2 and vary among countries in function of the latent covariates u_i, i.e., u_i is the unobserved heterogeneity characterizing the different socio-economic structure among countries, correlated for the different $\boldsymbol{\beta}$. Conditional on the set of covariates, we allow the parameter vector $\boldsymbol{\beta} = \{\boldsymbol{\beta^{\mathsf{T}}}_{0i}\boldsymbol{\beta^{\mathsf{T}}}_{1i}, \boldsymbol{\beta^{\mathsf{T}}}_{2i}\}$ to vary among the i countries. Given the conditional independent assumption, by assuming that the dependent variable is drawn from the normal distribution, the mixture model becomes:

$$\begin{aligned} f_i &= f(\mathbf{y}_i \mid \mathbf{x}_i, \mathbf{u}_i) = \prod_{t=1}^{T} \{f(y_{it} \mid x_{it}, u_i)\} = \qquad (6) \\ &= \prod_{t=1}^{T} f_{it} = \prod_{t=1}^{T} \left\{ \frac{1}{\sqrt{2\pi}\sigma} \exp\left[-\frac{1}{2\sigma^2} (y_{it} - (\beta_0 + u_i) - x_{it1}(\beta_1 + u_i) - x_{it2}(\beta_2 + u_i))^2 \right] \right\} \end{aligned}$$

Since the latent variables is unknown, we have to integrate it out. Moreover, in order to have no restrictive assumption on the distribution of $\mathbf{u}_i$, we leave $G(\cdot)$ completely unspecified, obtaining the following likelihood function:

$$L(\cdot) = \prod_{i=1}^{n} \left\{ \int_u f_i \mathrm{d}G(\mathbf{u}_i) \right\} \tag{7}$$

Furthermore, since we believe that the *prior* probability of belonging to a certain groups k is affected by the country-specific socio-economic structure, as the GDP per capita, the education level and the tax burden, we allow the weights of the mixture density to depend on these variables. Formally, let c the set of concomitant variables, such that $c = f(gdp_{i,95}, t_{i,95}, educ_{i,95})$, as discussed in Section 3, and α the associate parameter vector, such that we can rewrite the prior probability as $\pi_k = f(c, \alpha)$, where $\forall c \sum_{k=1}^{K} \pi(c, \alpha) = 1$ and $\pi(c, \alpha) > 0$. Following Dayton and Mcready (1988), a multinomial logit model is assumed for π_k, where the first component is the baseline (e.g., McLachlan and Peel, 2000) model to estimate the weights of the mixture:

$$\pi_k(c, \alpha) = \frac{e^{c^{\mathsf{T}}\alpha_k}}{\sum_1^K e^{c^{\mathsf{T}}\alpha_k}} \tag{8}$$

And the estimated posterior probability is

$$\hat{w_{ik}} = p(u_i = 1|y_i) = \frac{\pi_k(c, \alpha) f(\mathbf{y}_i | \mathbf{x}_i, \mathbf{u}_k)}{\sum_1^K \pi_k(c, \alpha) f_{ik}} \tag{9}$$

where $\mathbf{x}_i = \{x_{it}^1, x_{it}^2\}$ Thus, by approximating the integral in (7) as a sum on a finite number of locations K, the resulting likelihood function is:

$$L(\cdot) = \prod_{i=1}^{n} \left\{ \sum_{k=1}^{K} f(\mathbf{y}_i | \mathbf{x}_i, \mathbf{u}_k) \pi_k(c, \alpha) \right\} = \prod_{i=1}^{n} \left\{ \sum_{k=1}^{K} [f_{ik} \pi_k(c, \alpha)] \right\} \tag{10}$$

where for sake of simplicity we denotes with $f_i k = f(\mathbf{y}_i | \mathbf{x}_i, \mathbf{u}_k)$ the response distribution in the k-th component of the finite mixture.
In order to get the parameter estimation, let $\boldsymbol{\delta} = (\boldsymbol{\beta}_{0k}, \boldsymbol{\beta}_{1k}, \boldsymbol{\beta}_{2k}, \alpha_k, \pi_1, \ldots, \pi_{k-1}, \mathbf{u}_i, \sigma_u^2)$[16] the *complete* vector containing the unknown parameters of the model. Let K to be treated as fixed and estimated via penalized likelihood criteria in the parameters estimation process[17].

Neverthless, since the label component indicators is missing, the EM algorithm naturally arises to get the ML estimation. Formally, let $\mathbf{y}_i^c$ the complete data vector containing the feature data and the unobservable component indicators $\mathbf{z}_i$, where $\mathbf{z}_i = (z_{i1}, \ldots, z_{iK})$ is the unobservable vector of component indicators, containing dummies variable z_{ik} equal to 1, if the observation i has been drawn from the k component of the mixture, and 0 otherwise. Thus the complete data likelihood reads:

$$L(\cdot) = \prod_{i=1}^{n} \prod_{k=1}^{K} \{\pi_k(c, \alpha) f(\mathbf{y}_i | \mathbf{x}_i, \mathbf{u}_k)\}^{z_{ik}} \tag{11}$$

and the corresponding complete data log-likelihood reads as follows:

$$\ell_c(\cdot) = \sum_{i=1}^{n} \sum_{k=1}^{K} \hat{z}_{ik} \left[\log(\pi_k(c, \alpha)) + \sum_i \log(f_{ik}) \right] \tag{12}$$

The complete parameters vector's estimates are simultaneously obtained by performing the EM algorithm. For computational details see, among others, Dayton and Mcready (1988).
Summing up, by performing a finite mixture model with concomitant variables, we get the $\boldsymbol{\delta}$ parameter vector's estimation, that tell us the heterogeneous impact of the set of the covariates and concomitant variables on the corruption perception. In fact, as a results of the mixture we get the estimated number of clusters, say k, compatible with the data. Each group is characterized by homogeneous values of the estimated random effect. In addition, by using penalized likelihood criteria we identify locations of each observation. Thus, we obtain the prior probability for each country of belonging to cluster k, given the concomitant variable c and its parameter α. Furthermore, by getting the parameter α estimation[18], we identify whether the concomitant variable can affect the probability for each country of belonging to a certain cluster, with respect to the benchmark group (group 1). Furthermore, the (probability) clusters are obtained once the model has been fitted through the maximum likelihood estimator, in terms of fitted posterior probabilities of component membership of the data[19]. Summing up, estimating equation (5) by using the mixture model approach, allows us to deal with the error-in-variable bias and the unobserved heterogeneity, by imposing a latent structure for the covariates (Aitkin and Rocci, 2001; McCullogh and Nelder, 2001; Alfó and Trovato, 2004). Furthermore, by performing the EM algorithm we obtain also the country specific probability

[16]Since the prior probabilities by definition sum up to 1, one of the mixing proportion is redundant

[17]In fact, in order to deal with the model specification uncertainty, and to choose the number of cluster, it is possible to use penalized likelihood criteria, as AIC, BIC, ICL as well as Bayesian inference (McLachlan and Peel, 2000).

[18]From a computational point of view, as stressed by Grünn and Leish (2008) and Dayton and Macready (1988) the concomitant variables are to be simultaneously estimated in the EM process.

[19]See among others Alfó et al., (2008) for computational detail

to belong to a specific group in which countries share the same effect of the latent variable, i.e., the homogeneity assumption holds in the subgroups. In the following we present data's and results' sections.

5 Data and variables definition

Our work is based on an unbalanced panel for 129 countries from 1995 to 2006.
The indicator for corruption in public sector is the Corruption Perception Index (CPI) provided by Transparency International. It covers 130 countries[20] from 1995, and it is one of the most reliable database for cross country analysis on corruption. The index is constructed by aggregating various sources of survey data, at most 13, and it ranges between 0 and 10 such that the highest the score, the lowest the extension of corruption.
As argued in the introduction and in the literature review section, despite its widespread use, the CPI is affected by some criticisms. Nevertheless, corruption perception and actual level of corruption within countries are found to be closely related (see among others, Fisman and Miguel, 2006), so CPI could be considered an useful (even if not exhaustive) measure for corruption to be used with "prudence". For this reason, we employ CPI as dependent variable taking into account that our results concern the perceived level of corruption across countries. As pointed out in Section 3, we identify two macro *independent* sets, i.e. the *risk of punishment* and the *economics incentive*, as the main determinants of the perceived level of corruption. We assume that each of the above macro "baskets" can be affected by other variables, as formalized in equation 2 and 3.
In fact, the *risk of punishment* is here thought to depend on *macro* and *micro* level factors. As macro measures we consider government size, democracy and government fractionalization (respectively gs_{it}, d_{it} and the ps_{it}); while as micro measures the perceived level of protection of civil and political rights, r_{it}, and the degree of independence of judiciary system, j_{it}. The macro factors affecting the *risk of punishment* are proxied by:

- *gce* as a measure for government size. Following the economics literature, we use the general government final consumption expenditure as percentage of the GDP (World Development Indicators, $http://data.worldbank.org$);
- *demo* as a measure of democracy. It is a dummy equal to 1 if the regime is democratic and 0 otherwise (Cheibub, Gandhi and Vreeland database $http://www.systemicpeace.org/polity/polity4.htm$);
- *ovs* as measure of Parliament power during the legislative iter (vote of opposition parties over total votes) (Cheibub, Gandhi and Vreeland database, $http://www.systemicpeace.org/polity/polity4.htm$).

We proxy the micro level variables affecting the risk of punishment using:

- *status* as a measure of the level of political rights and civil liberties ($http://www.freedomhouse.org$). This is a categorical variable coded 1 if the protection is complete, 2 if it is partly, and 3 if it is absent;
- *jud*, as a dummy variable coded 1 if there is an independent judiciary, and 0 otherwise (Henisz political constraints index, $http://www-management.wharton.upenn.edu/henisz/$).

[20] In our panel we do not consider Libya, because of the lack of quantitative data in the independent variables.

The most of the explicative sub-set of variables affecting the *economics incentive* are retrieved from the Heritage Foundation (data can be found at $http://www.heritage.org/index/download$). All those indexes range between 0 and 100, where the highest the score, the highest the level of freedom. They consist on three different measures of economics and financial country-specific environment. We use as proxies for variables in equation 3 (b_{it}, f_{it} and o_{it} standing for respectively bureaucracy, finance and openness) the following measures:

- $business$, as a measure of the freedom to start business activities in no-financial sector;
- $finance$, as a measure of the government intervention in the financial service, and of the freedom of opening and operating financial services firms.
- $openk$, as a measure of *openness to trade* at constant price at 2005 (Penn World Table 8.0,
$http://www.rug.nl/research/ggdc/data/penn-world-table$).

Furthermore, we model the probabilities, for each country of belonging to a certain cluster, as conditioned on specific initial level variables (fixed at year 1995). To capture the economic and social country-specific environment, we use as concomitant variables:

- $fiscal_{95}$: the initial level of the composite index measuring the State fiscal policy over individuals and firms (Heritage Foundation);
- $educ_{95}$: the initial level of the average number of years of education of men, aged 25 and older (The Quality of Government Institute, University of Gothenburg);
- $rgdpch_{95}$: the initial level of per capita income (Penn World Table 8.0).

Table 2 describes the data (as average of the index, or as frequency) on the basis of the level of corruption. Following the Transparency International, we divide corruption in three categories, high, medium and low according to the index score. An index between 0-3 is associated to high corruption, 4-6 with medium corruption, and 7-10 to low corruption.

Insert Table 2 about here

Descriptive statistics seem to confirm that political setting as well as economics variables are strictly related to the extent of corruption. Even if the average of some country fundamentals (democracy, independent judiciary, education, as well as business and financial freedom) presents the expected relation with corruption perception, others variables have an uncommon relation with corruption. For example, the protection of political and civil rights is ensured more in countries with a medium corruption perception, both in terms of index average and frequency, rather than in low corrupted countries. Regarding to two debated variables, GDP per capita, government size (in terms of public expenditure) and government intervention, data distribution shows that low corruption is more reasonable in the richest countries, characterized by the highest government size, and the lowest intervention of the State in the economics environment, even if the difference in the fiscal index is low among low and medium corrupt countries.
Before proceeding to analyze the estimation results, it is useful to have a look at the response variable distribution, in order to better understand that the need of clustering the entire sample in sub-populations is due also to the uncommon distribution of the CPI. In fact, by looking at the CPI density, it seems more reasonable to consider it as a mixture of a normal variables, rather than as a common normal distribution (see Figure 1).

Insert Figure 1 and Table 3 about here

Table 3 displays summary statistics for the Corruption Perception Index. Skewness and kurtosis, of 0.79 and 2.38 respectively, show a departure from the symmetric and flatness common measure of the normal distribution. In order to formally complement the hypothesis of the non-normal distribution characterizing the corruption perception index, the Q-Q Plot and the Shapiro-Wilk test are performed. As it is shown in Figure 2, data points do not follow the line very closely, especially in the tail, stressing a departure from normality of the sample data.

Insert Figure 2 about here

Shapiro-Wilk and Anderson and Darling normality test (Shapiro and Wilk, 1965 and Anderson and Darling, 1954) show that the null hypothesis of normal distribution of the data could not be accepted (p-values for H_0 is $p - value = 2.2e^{-16}$ for both tests; A statistics for Anderson and Darling test is equal to 42.1073 and W statistics, for the Shapiro and Wilk test 0.8901).

6 Results

In this section we present the results obtained by estimating the model from equation (5), using firstly GLS model and OLS with Fixed Effect, as parametric benchmark. Then we proceed by showing parameter estimation resulting from a finite mixture with concomitant variables model.
Parameter estimates for both GLS and OLS with Fixed Effect (FE) approach are presented in Table 4. The GLS estimation is considered as a parametric benchmark.

Insert Table 4 about here

In contrast with the Bilger and Goel (2009) results about the role of the State (but in line with those of Fisman and Gatti, 2002), the $\hat{\beta}$ for gce variable is equal to 0.572 and it is statistically significantly different from zero (see Table 4), suggesting a negative correlation between Government size and corruption perception (it is worth reminding that the CPI index goes from 0, highest level of perceived corruption, to 10, absence of corruption). Moreover, GLS results do not display a significant statistical association among fiscal policy ($fisc_{95}$) and corruption. Table 4 provides evidence consistent with the literature for the main country fundamentals (empowerment rights, financial and business index), even if the openness to trade is found to be not correlated with corruption, i.e. international competition is not a deterrent for corrupt activities. OLS with FE estimation presents statistically significant association among dependent and explanatory variables only for finance ($\hat{\beta} = 0.004$), democracy ($\hat{\beta} = -0.29$) and judiciary independence indexes ($\hat{\beta} = 0.272$), and in each case the impact of those variables is lower than the once found by the GLS procedure.
In the next step, we present results of the finite mixture approach conditioning the prior probability to the initial level variables, i.e. the concomitant variables (see equations (8) and (9)). This allows for avoiding empirical problems due to both the possible feedback effect between the initial level variables ($fiscal_{95}, educ_{95}, rgdpch_{95}$) and the subject specific and time varying covariates (rp_{it} and ei_{it}), and to the endogeneity relations between CPI and concomitant variables (see, among others, Dayton and Mcready, 1988).
After conditioning the weights of the mixture to depend on concomitant variables, data shows at least six different impacts of covariates over CPI. In fact, as showed in Table 5, penalized

criteria (BIC, AIC and ICL) values have been minimized with a discrete model log-likelihood with 6 components.

Insert Table 5 about here

Since the ratio between the number of observations assigned to the corresponding clusters and the one where the posterior probability is greater than N (with $n = 10^{-4}$) is around 0.7 in all sub-groups, but the first, we have evidence of medium well-separated components (see Table 6). This implies that there is not a significant overlap with other components, but for the first and the second (McLachlan and Peel, 2000).

Insert Table 6 about here

Thus, we can suppose the existence of distinct socio-economic rules characterizing countries in separated groups (at least in our sample). Table 7 displays parameters estimates from a finite mixture model with concomitant variables, showing that political, social and economic country-determinants vary their impact in terms of sign and magnitude on corruption perception among the different countries in the distinct clusters. This could lead to various (and divergent too) country specific explanations about the link between the phenomenon and its determinants.

Insert Table 7 about here

Indeed, corruption interplays with political, social, and economic environments, since, as it is formalized in Section 3, the interaction between the demander of corrupt activities (private corrupter agent) and the supplier (public official) seems to depend on the expected costs of being getting caught i.e. *risk of punishment*, and on the expected benefit from the corrupt activity, i.e. *economics incentive* given by the environment. In our specification, we have assumed that the above theory-based macro explanations could be measured by the sign and significance of the estimated parameters associated to the matrices $\mathrm{x}^1_{it} = (status_{it}, demoit, ovsit, judit, gceit)$, and $\mathrm{x}^2_{it} = (business_{it}, finance_{it}, openk_{it})$ for *risk of punishment* and *economics incentive* respectively. Since we allow for formally including the unobserved heterogeneity in the parameters estimation process through the random effect u_k, we will get different estimated parameters for different groups of countries if and only if the unobservable environment (such as for example the sense of the justice, cultural or religious features and so on) affects the Data Generation Process (DGP) of the country-specific CPI index. Furthermore, since corruption is the reflection of the individual decision process, the above mentioned covariates could depend in turn on subjective factors, as tastes and preferences. In other words, the existence of $\hat{\beta}$ parameters varying across sub-populations gives empirical evidence on how individual factors could differently affect the extension of corruption across countries.
For this reason, the most interesting result is the changing in sign of the parameters associated to the role of the Institution in fighting corruption, in terms of size and market intervention. As hinted before, the impact of the government expenditure on the expected cost in undertaking a corrupt activity depends on the individual perception about the strengthen of Institution in fighting corruption, that in turn depends on the individual perception about the government role. In fact, even if the structural characteristics of the Government are thought to affect demand for corrupt activities (Ackerman, 1998), the actual effect on corruption depends on how

monitoring activity of the State is seen to be by agents. According to the literature debate, it is not surprising that in the first, fourth, fifth, and sixth component the government size has a positive (even if different in terms of magnitude) effect on corruption, confirming Bilger and Goel (2009) results, while in the second cluster it is negative, empirically proving that the increase in the public spending could give rise to rent-seeking (Fisman and Gatti, 2002). In fact, despite the quite similar value of the government expenditure among class 2, 3 and 4 (see Table 9 for cluster composition and Table 10 summary statistics divided by cluster), the impact on corruption is highly different among the three sub-populations. Indeed, the $\hat{\beta}$ parameter associated to the *gce* covariate is significant in the second and fourth component, and it is respectively equal to -2.224 and 3.107, while is not statistically different from zero in the third group. This could be explained by the latent structure conditioning the parameters estimates. In fact, as it will be better explained in the following, since the country fundamentals characterizing countries in class 4 are good (see Table 9 and Table 10), an increase in the government expenditure could not leave room for corruption. Opposite result is obtained in class 2.

In line with the idea that government intervention could create room for corruption, as well as could deter it, it is worth noting that also the State intervention in the economics activity has discordant effect on corruption. Indeed, the financial freedom index is found to discourage the likelihood of asking for and/or accepting a bribe in all components, but the fourth. Class 3, including a mix of developed countries (see Table 9) with an index average of CPI and openness to trade lower than the one of class 4 but highest than the others (see Table 10), is characterized by a negative impact of the "financial freedom", (see Table 7), with a $\hat{\beta}$ parameter associated to *finance* equal to -0.0049. We recall that this index is formed by two indistinct components: the degree of intervention of the State in the financial system, and the difficulty of opening and closing a financial service activities, also for foreign firms. At this point, it seems reasonable to relate the negative impact to the first component, suggesting that for countries belonging to the fourth component, it seems reasonable to conclude the highest the intervention of the State in the financial system, the highest the corruption perception.

To complement the analysis of government intervention, we account also for the role of democracy, as it is common in the economics literature on corruption. Democracy is found to be significantly different from zero only in the first group (where the $\hat{\beta}$ parameter associated to *demo* is equal to -0.5762, confirming our idea of changing in the effect of the role of the State in fighting corruption.

No discordant results, according to our knowledge, are achieved in literature on the effect of the independent judiciary system on corruption. For this reason, it is not surprising that the parameter associated to this variable has always the same effect in terms of sign and statistically significant in all clusters. This is due to the fact that the presence of an independent judiciary system, by increasing the perception about the capability of the State in ensuring compliance with the law, increases the perceived risk of punishment that in turn decreases corrupt acts. At this point it is worth noting that despite class 5 and class 6 have a similar economics and political structure, only empowerment rights, judiciary independence index and government size affect corruption pattern in class 6 (business and finance freedom index's coefficient are significant but quite small), suggesting that in this cluster the role of the State in increasing the perceived compliance with the law is the unique variable affecting the corruption perception. On the other hand, estimated parameters in class 5 suggest that both the risk of punishment and the economics incentive in undertaking a corrupt activities significantly impact on corruption, even if the magnitude of the economics variable is low, but openness to trade.

In line with the literature debate, the perception on how the economics incentive could affect the extent of corruption is not unique. Our results confirm the idea that international competition decreases the extension of corruption. In fact, by increasing competition firms face a reduction in the extra profit used for paying bribe (see among others, Ades and Di Tella, 1999; Robertson and Watson, 2004 and Lambsbdorff, 1999); at the same time competition increases the monitoring activity played by other firms in the market, that in turn has a deterrent power on corrupted actions. Moreover, openness to trade is found here to have a deterrent role for the first, second and fifth component. In the other groups the impact on corruption is not statistically significant different from zero.

According to our theoretical framework (see Section 3), the will of avoiding the bureaucratic system is the main economics incentive discouraging incentive of undertaking a corrupt activity, since the parameter associated to the business index does not change its impact in terms of sign, but it is not statistically significantly different from zero in the second component.

In order to understand if the differences among countries in the corruption patterns could be due also to the different starting points in the GDP per capita, the tax burden and the education quantity, we directly modeled prior probabilities of belonging to a certain cluster through concomitant variables.

Table 8 shows us the impact of the initial conditions on corruption patterns in different clusters, by taking the first category as benchmark. Our benchmark (group 1) contains medium corrupted countries (CPI around 4.2, with standard error of 1.18), with a negative random term and the highest "fiscal freedom index" (i.e., the lowest tax burden).

Insert Table 8 about here

The starting condition that mainly affect the corruption perception is the GDP per capita measured in 1995. In fact, the wealth per capita increases the likelihood of belonging to the two "virtuous" groups (3 and 4) and to class 2 (containing medium income countries, with CPI around 5.0) relative to that of belonging to the benchmark group 1. On the other hand, the GDP per capita decreases the likelihood of belonging to the two poorest groups (class 5 and 6). Coherently with the economics literature, the initial level of GDP has different impact on corruption. In fact, the high level of GDP could be associated with an high amount of government resources and also to an high demand for institutional change and, thus, better government (Svensson, 2005). Moreover, the procyclical nature of corruption is the theoretical framework used to justify the negative effect on the extent of corruption, as it is derived for the sixth component (Braun and Di Tella, 2004). As Table 8 shows, the initial level of education in 1995 has a significant explanatory variable only in class 6, meaning that the quality of education raises the likelihood of belonging to class 6 (the highest corrupted) relative to that of belonging to the benchmark group. It is worth noting that even if class 6 is one of the poorest group (in terms of the GDP per capita) and with the lowest corruption perception index, the quality of education is relative high to that of class 1. Summing up, the economics structure is the main factor affecting the likelihood of belonging to "virtuous" groups.

Table 9 illustrates the country (posterior) classification.

Insert Table 9 about here

As showed in Table 9, countries' classification in clusters (by using the finite mixture approach) is sufficiently satisfactory, and the estimated classes show evidence of homogeneity within groups.

In fact, by having a look at the clusters' composition, it seems clear that the "virtuous" countries, both in terms of corruption perception and country-fundamentals (see Table 10 for further detail on the independent variable summary statistics), are all clustered in class 4, in which the key country-characteristics affecting the corruption pattern are the business and the judiciary independence index, as well as is among others the government expenditure. Class 5, with both a statistically significant value of the random term, include the poorest countries, with the highest tax burden.

Summing up, results obtained by using a finite mixture show how the country-specific fundamentals affect in different way the corruption patterns among countries, supporting our idea that in order to obtain coherent measure of the determinants of corruption, it could be better to take into account that the homogeneity assumption does not hold in the entire sample. In fact, the incentives of asking for and/or being ask for a bribe change their impacts according to the country environment. As it is noticed above, debate in literature is due to the omission of the individual characteristic of the phenomenon itself. It is worth noting that the result we get form a GLS estimation on the international competition is not reasonable. In fact, GLS estimation does not capture the deterrent effect on corrupt activities of openness to trade, while the finite mixture approach does. Thus, the parameter estimation we get from applying a finite mixture model to the here considered sample seems to suggest an improvement in the description of the phenomenon.

Furthermore, despite parametric benchmark models deal with heteroscedasticity, heterogeneity and orthogonality among explanatory variables, they are not able to solve simultaneously the above mentioned empirical problems affecting the estimation procedure. In fact, by comparing the empirical density of the CPI, and the estimated density obtained by using the finite mixture and the GLS approach (see Figure 3), it is clear that the data generating process for our sample is better approximate by the mixture, rather than the parametric approach.

Insert Figure 3 about here

The empirical density shows a strong evidence of the presence of heterogeneity in the sample, confirmed by the parameters estimates obtained by employing finite mixture model.

6.1 Model Diagnostic

Since the finite mixture model is a semi-parametric approach, standard parametric goodness of fit can not be applied in order to verify the goodness of fit of our model. Firstly, following Aitkin (1997) and McLachlan and Peel (2000), we compare the empirical distribution function of the observed data with the cumulative distribution function (CDF) of the model fitted by finite mixture and the once by the GLS. As it is shown in Figure 5, the estimated CDP of the finite mixture provides a better fit of the data than the once of the GLS.

Insert Figure 5 about here

In order to test whether the estimated number of non-overlapping groups is compatible with the data, as suggested by Aitkin et al. (1981), we apply the bootstrap approach to a finite mixture model (B=1000). In fact, in mixture model analysis it is well known that we can not approach to this problem by using a simple likelihood ratio test (e.g., McLachlan, 1987), because the regularity conditions do not hold for the log-likelihood statistic distribution[21]. In

[21]It has not the usual asymptotic distribution under the null and the alternative hypothesis.

order to test the likelihood of having 6 sub-groups, following the Romano (1988) bootstrap based approach procedure, we perform a test of hypothesis as follows:

$$\begin{cases} H_0 & k = j \\ H_1 & k > j \text{ or } k < j \text{ with } j = k \end{cases}$$

Thus, we use the resampling method to assess the null distribution on the basis of a number, say B (B=1000), of bootstrap replications of the log-likelihood statistic by an appropriate resampling (McLachlan, 1987).

In order to check if the data are characterized by an *unimodal* distribution, we test the hypothesis $j = 1$ as in (6.1).

Insert Table 11 about here

As reported in Table 11, data show evidence of multimodality. In fact, since the *p-value* is equal to 0.0102 we can reject the null (unimodality) in favour of the alternative that states the multimodality distribution of the data. We repeat the test for the null hypothesis that data are drawn from exactly a 6-component finite mixture following the same bootstrap-based procedure ($B = 10000$). This is equivalent to rewrite the hypothesis test in (6.1) as follows:

$$\begin{cases} H_0 & k = 6 \\ H_1 & k > 6 \text{ or } k < 6 \end{cases}$$

As Table 11 shows, we can state that having 6 sub-group is reasonable according to the data. In fact, when the p-value associated to the hypothesis test as in (6.1) lead us to not reject the null.

7 Conclusion

The paper empirically tests the hypothesis that the individual decision process of undertaking a corrupt activity varies according to specific fundamentals, as well as unobservable and/or no-measurable variables (such as individual tastes and preferences, attitude toward risk, propensity of committing criminal acts), i.e. the heterogeneity is due to unobserved latent differences between the economics, political and social country-specific environments. By applying a finite mixture model with concomitant variables we give a possible solution to some empirical problems affecting cross-country corruption analysis. Firstly, the latent structure for the explanatory variables allows us to take into account the country-specific heterogeneity and dependence among covariates. At the same time, we allow for the country specific prior probabilities of belonging to a certain cluster depending on its initial conditions in the socio-economics structure. In fact, once the prior probabilities are conditioned on the initial level of the real GDP per capita, the tax burden and the education quantity, countries are clustered in six groups in which the homogeneity assumption holds, i.e., the determinants of corruption have the same impact within groups. The Romano test and Penalized criteria likelihood confirm the presence of heterogeneity, as well as the empirical distribution function shows that the best fit of the model is obtained once the finite mixture model is employed. The role of the State, the most debatable in literature, is found to vary among sub-groups, according to the unobserved latent structure determining the perception about the expected costs and gains deriving from a corrupt activity. In fact, government expenditure is found to not leave room for corruption but to highly increase the individual perception about the risk of punishment in some clusters (composed for example by Norway, United Kingdom, Canada and so on); while it is found to leave room for corruption in countries as Italy or Spain. Furthermore, we showed that the will of avoiding the bureaucratic system is the main economics incentive in undertaking a corrupt activity, while the presence of an independent judiciary system increases the perception about the capability of the State in ensuring compliance with the law. We also provided some evidence that the highest the initial level of GDP per capita, the highest the probability for each country of belonging to the virtuous group.

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Table 1: The impact of economic fundamentals on corruption

Economic variables	High Corruption	Low corruption
Income per capita	Braun and Di Tella (2004) Frechette (2006)	Paldam (2000) Husted (1999) Svensonn (2005)
Government size	Ali and Isse (2003) Goel and Nelson (1998)	Fisman and Gatti (2002) Adserá et al. (2003)
Government intervention	Treisman (2000) Acemoglou et al. (2000)	Friedman (2000)

Notes: *income per capita*: GDP per capita; *government size*: public expenditure in final goods as share of GDP; *government intervention*: estimated in the form of regulation, taxation; *competition*: openness to trade, proxy as share of imports in GDP.

Table 2: Mean of covariates classified for high, medium and low CPI

	High	Medium	Low
Risk of punishment			
Democracy*	0.54	0.70	0.94
Opposition Vote Share	21.10	32.99	45.22
Status of civil and political rights			
Free*	61	315	201
Partially Free*	197	115	12
Not Free*	93	52	0
Independent Judiciary*	0.32	0.60	1.00
Government Expenditure (% of GDP)	12.43	16.12	19.03
Economics Incentive			
Business Freedom	38.58	52.44	66.53
Financial Freedom	45.36	56.41	73.10
Openness to Trade	72.22	85.83	89.10
Fiscal Freedom	83.09	80.44	70.95
Socio Economics Factors			
Real GDP per capita	4276.38	12178.08	29788.26
Education (Male average schooling)	6.93	8.37	11.45
Geographical Classification*			
Eastern Europe, post Sovietic Union	75	103	0
Latin America	78	86	8
Middle Est, North Africa	13	82	6
Sub-Saharan Africa	108	79	0
Western Europe, North America	1	58	181
East Asia	6	28	6
South Est Asia	36	27	12
South Asia	132	6	0
Caribbean	2	13	0

Notes: ∗ values are frequencies
The dependent variable, the *corruption perception index*, is divided in three categories, high, medium and low according to the index score. An index between 0-3 is associated to high corruption, 4-6 with medium corruption, and 7-10 to low corruption. The table shows the mean value of the covariates affecting the corruption level, divided for the macro-area presented in the paper: *risk of punishment*, *economics incentive* and *socio economics factors*. The *geographical classification* shows the number of countries in each geographic area that are characterized by high, low or medium level of corruption.

Table 3: Corruption Perception Index: Summary Statistics

variable	**mean**	**sd**	**skewness**	**kurtosis**	**min**	**max**	**N**
cpi	4.6068	2.3255	.7927	2.3815	0.4	10	1046

Notes: The Table displays summary statistics for the corruption perception index, showing: mean, standard error, skewness, kurtosis, maximum and minimum value.

Table 4: GLS and OLS with FE result

Variable	Coefficient	GLS Stand. Error	Coeff	OLS with FE St. Error
trend	-0.0410	0.0136 **	-0.0003	0.0065
business	0.0217	0.0028 ***	0.0024	0.00124
finance	0.0177	0.0024 ***	0.0042	0.0015 **
status,Partfree	-0.5009	0.1115 ***	0.1395	0.1340
status,Notfree	-0.2504	0.1822	0.0912	0.1050
demo	-0.4799	0.1214 ***	-0.2905	0.1171 *
ovs	0.0051	0.0022 *	0.0015	0.0012
jud	0.8594	0.0975 ***	0.2727	0.0767 ***
gce	0.5719	0.1246 ***	0.1113	0.1323
openk	-0.0014	0.0780	0.1497	0.1314
educ_95	-0.5241	0.1394 ***		
rgdpch_95	1.1702	0.0588 ***		
fiscal_95	-0.0874	0.2743		
(Intercept)	-7.7376	1.4132 ***	3.2004	0.6517 ***
ℓ	-1692.219			
BIC	3481.602			
n	1046			

Significance level: $***: 0.1\%$ $**: 1\%$ $*: 5\%$ $.: 10\%$

Notes: Dependent variable: Corruption Perception Index; *business*: business freedom indicator (Heritage Foundation); *finance*: financial freedom indicator (Heritage Foundation); *status*: categorical variable for the political and civil rights (Freedom House); *demo*: dummy variable on the Democracy (Cheibub, Gandhi and Vreeland database); *ovs*: total votal share of all the parties in the opposition (Database of Political Institution); *jud*: dummy variable on judiciary independence (Henisz Index); *gce*: government consumption expenditure as a share of GDP (World Bank Database); *openk*: openness to trade (Penn World Table); *educ_95*: average years of schooling for men aged 25 or over (University of Washington); *rgdpch_95*: real GDP per capita (Penn World Table); *fiscal_95*: fiscal freedom indicator (Heritage Foundation).
BIC$=-2\ell(.) + d\log(n)$, where ℓ is the log-likelihood, d the number of parameters and n the sample size.

Table 5: Penalized criteria for finite mixture model

	iter	converged	k	k0	logLK	AIC	BIC	ICL
2	23	TRUE	2	2	-1218.5318	2493.064	2631.740	2633.313
3	21	TRUE	3	3	-1009.9007	2107.801	2325.722	2329.087
4	24	TRUE	4	4	-881.3361	1882.672	2179.836	2194.763
5	35	TRUE	5	5	-812.2970	1776.594	2153.001	2165.143
6	29	TRUE	6	6	-742.9693	1669.939	2125.590	2141.418
7	21	TRUE	6	7	-794.5870	1773.174	2228.825	2248.232

Notes: K number of components; logLK, log-likelihood
AIC= $-2\ell(.) + d$
BIC= $-2\ell(.) + d\log(n)$
ICL= $BIC + entropy$
where d is the number of parameters and n is the sample size

Table 6: Finite Mixture Model: prior probabilities

K	**prior**	**size**	**post**	**ratio**
1	0.1571	158	280	0.564
2	0.0825	102	162	0.63
3	0.0871	115	163	0.706
4	0.0944	136	204	0.667
5	0.2228	195	305	0.639
6	0.356	340	455	0.747

Notes: K number of components; *prior*: probability to belonging to that group k; *size*: number of country belonging to that group k; *post*: number of country belonging to that group after estimation; *ratio*: the ratio between size and post.

Table 7: Finite Mixture estimation

Variable	**1 Comp.**	**2 Comp.**	**3 Comp.**	**4 Comp.**	**5 Comp.**	**6 Comp.**
(Intercept)	-0.8574 .	2.0479	2.8143	-2.3754	-1.3803 0***	1.0547 ***
trend	-0.0430 ***	0.1242 ***	0.0089	-0.0444 ***	-0.1178 ***	0.0012
business	0.0152 ***	-0.0067	0.0142 ***	0.0102 **	0.0091 ***	0.0071 ***
finance	0.0073 **	0.0328 ***	0.0497 ***	-0.0049 .	0.0076 ***	0.0076 ***
status,Partfree	-0.6181 ***	-0.8302 *	-3.2011	-0.9347	-0.3111 ***	-0.5907 ***
status,Notfree	-1.4302 ***	0.2356	-2.4365	-1.499	-1.1663 ***	-0.1272
demo	-0.5762 9***	0.6422	-1.0685	-3.0838	-0.112	-0.0166
ovs	0.0115 ***	0.0119 *	-0.0021	0.0046	0.0097 ***	-0.0006
jud	0.4069 ***	0.5752 *	1.2455 2 **	3.9643 ***	0.6114 ***	0.3771 ***
gce	0.7118 ***	-2.2242 ***	0.0949 4	3.1077 8***	0.2067 .	0.4199 ***
openk	0.5895 ***	1.3709 ***	0.0663 9	0.1298 2	0.9787 ***	0.0226
σ_k	0.392	0.6797	0.5201	0.4091	0.3543	0.4689
ℓ	-742.9693					
n	1046					

Significance level: $***$: 0.1% $**$: 1% $*$: 5% . : 10%

Notes: Dependent variable: Corruption Perception Index; *business*: business freedom indicator (Heritage Foundation); *finance*: financial freedom indicator (Heritage Foundation); *status*: categorical variable for the political and civil rights (Freedom House); *demo*: dummy variable on the Democracy (Cheibub, Gandhi and Vreeland database); *ovs*: total votal share of all the parties in the opposition (Database of Political Institution); *jud*: dummy variable on judiciary independence (Henisz Index); *gce*: government consumption expenditure as a share of GDP (World Bank Database); *openk*: openness to trade (Penn World Table).

Table 8: Concomitant Effects

	2 Comp.	**3 Comp.**	**4 Comp.**	**5 Comp.**	**6 Comp.**
(Intercept)	-25.5949	-69.5700 *	-70.6190 *	-4.2521	7.5369
rgdpch_95	2.4270 *	4.9180 **	6.1325 **	-1.5626 *	-2.6403 ***
fiscal_95	0.9748	4.7713	1.9041	3.4193	1.5710
educ_95	-0.6948	0.6701	1.2017	1.5685	4.4596 ***

Significance level: $***$: 0.1% $**$: 1% $*$: 5% . : 10

Note: The dependent variable is the Corruption Perception Index. All the concomitant variables are taken fixed at their initial values. *educ_95*: average years of schooling for men aged 25 or over (University of Washington); *rgdpch_95*: real GDP per capita (Penn World Table); *fiscal_95*: fiscal freedom indicator (Heritage Foundation). The first component is the reference class.

Table 9: Countries' groups

Algeria	Belarus	Australia	Canada	Benin	Albania
Botswana	Belgium	Austria	Denmark	Cambodia	Argentina
Brazil	Colombia	Bahrain	Finland	Dominican Republic	Armenia
Burkina Faso	Italy	Chile	Germany	El Salvador	Azerbaijan
Cameroon	Malaysia	France	Ireland	Fiji	Bangladesh
Chad	Saudi Arabia	Israel	Netherlands	Ghana	Bolivia
Cyprus	Slovenia	Japan	Norway	Guinea	Bulgaria
Estonia	Spain	Kuwait	Oman	India	Burundi
Gabon	Tunisia	Portugal	Singapore	Jamaica	China
Greece	UAE	Switzerland	Sweden	Lithuania	Congo
Hungary	Uruguay	New Zealand	US	Madagascar	Croatia
Jordan			UK	Malawi	Czech Republic
Korea, South				Mauritania	Ecuador
Lebanon				Mexico	Egypt
Mali				Morocco	Gambia
Mauritius				Mozambique	Georgia
Niger				Namibia	Guyana
Peru				Poland	Honduras
South Africa				Senegal	Indonesia
Turkey				Sri Lanka	Iran
Nepal				Swaziland	Kenya
				Vietnam	Laos
				Yemen	Latvia
				Zimbabwe	Lesotho
					Moldova
					Mongolia
					Nicaragua
					Pakistan (1972-)
					Panama
					Paraguay
					Philippines
					Romania
					Russia
					Rwanda
					Slovakia
					Syria
					Tajikistan
					Tanzania
					Thailand
					Uganda
					Ukraine
					Uzbekistan
					Venezuela
					Zambia

Table 10: Summary Statistics

	1 Comp.		**2 Comp.**		**3 Comp.**		**4 Comp.**		**5 Comp.**		**6 Comp.**	
	Mean	**St.Err**	**Mean**	**St.Err**	**Mean**	**St.Err**	**Mean**	**St.Err**	**Mean**	**St.Err**	**Mean**	**St.Err**
cpi	4.178	1.181	5.073	1.288	7.520	1.215	8.642	0.854	3.383	0.855	2.769	0.715
fiscal	80.407	8.066	76.871	12.723	75.471	10.342	70.245	12.055	80.765	7.298	83.900	6.337
demo	0.595	0.492	0.637	0.483	0.930	0.256	0.882	0.323	0.636	0.482	0.638	0.481
status	1.532	0.711	1.725	0.834	1.070	0.256	1.147	0.431	1.662	0.702	1.879	0.721
jud	0.462	0.500	0.500	0.502	0.965	0.184	0.971	0.170	0.426	0.496	0.479	0.500
business	52.030	14.134	54.076	14.285	62.425	13.448	68.528	16.794	44.060	16.522	41.650	16.575
educ	7.684	2.900	8.763	1.879	10.459	1.944	11.417	1.918	6.323	2.614	8.269	2.667
openk	72.836	38.018	99.855	53.950	64.474	29.631	102.790	89.029	80.475	29.330	79.174	36.970
rgdpch	9933.697	6492.986	19124.695	9753.745	25861.541	6735.981	31152.730	5700.395	5410.012	4248.530	5675.590	4043.584
gce	15.056	4.855	17.314	3.824	18.184	4.625	19.785	4.641	13.002	4.802	13.891	4.491
finance	56.899	15.530	54.412	16.970	66.522	18.451	71.985	15.339	49.487	16.614	50.147	18.869
ovs	29.140	21.050	26.036	22.815	37.046	17.712	48.043	14.038	30.576	22.365	26.241	21.028
N	158		102		115		136		195		340	

Notes: *cpi* is the Corruption Perception Index.*business*: business freedom indicator (Heritage Foundation); *finance*: financial freedom indicator (Heritage Foundation); *status*: categorical variable for the political and civil rights (Freedom House); *demo*: dummy variable on the Democracy (Cheibub, Gandhi and Vreeland database); *ovs*: total votal share of all the parties in the opposition (Database of Political Institution); *jud*: dummy variable on judiciary independence (Henisz Index); *gce*: government consumption expenditure as a share of GDP (World Bank Database); *openk*: openness to trade (Penn World Table). *educ*: average years of schooling for men aged 25 or over (University of Washington); *rgdpch*: real GDP per capita (Penn World Table); *fiscal*: fiscal freedom indicator (Heritage Foundation). N is the number of observations in each component.

Table 11: Reported *p-value* for the bootstrapping likelihood ratio test

Hypothesis Test		**p-value**
$H_0 : k = 1$	$H_1 : k \geq 3$	0.0102
$H_0 : k = 2$	$H_1 : k \geq 3$	0.01818
$H_0 : k = 5$	$H_1 : k \geq 6$	0.02381
$H_0 : k = 6$	$H_1 : k \geq 7$	0.3793
$H_0 : k = 6$	$H_1 : k \leq 5$	0.9659
$H_0 : k = 7$	$H_1 : k \leq 6$	0.14

Figure 1: Density function: Corruption Perception Index

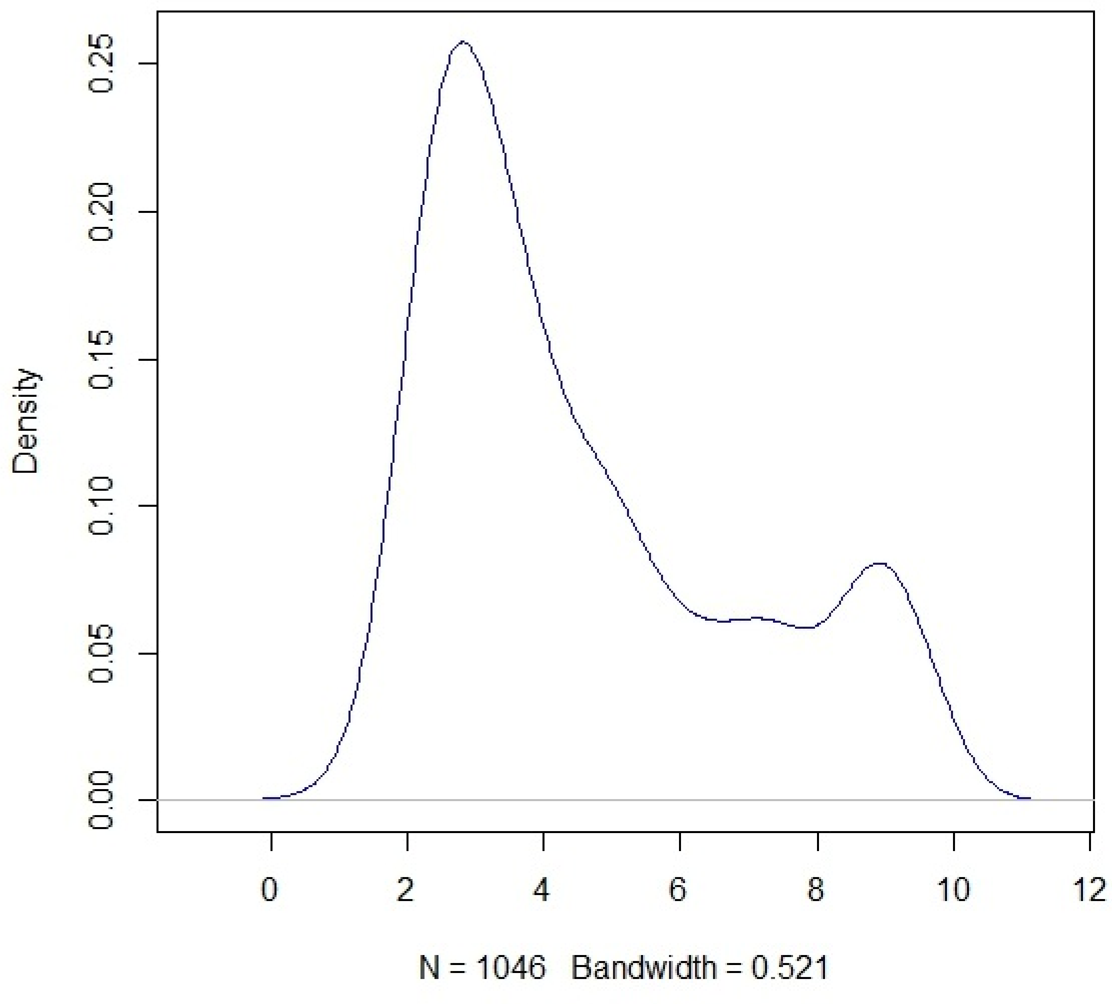

Figure 2: Q-Q Plot: Corruption Perception Index

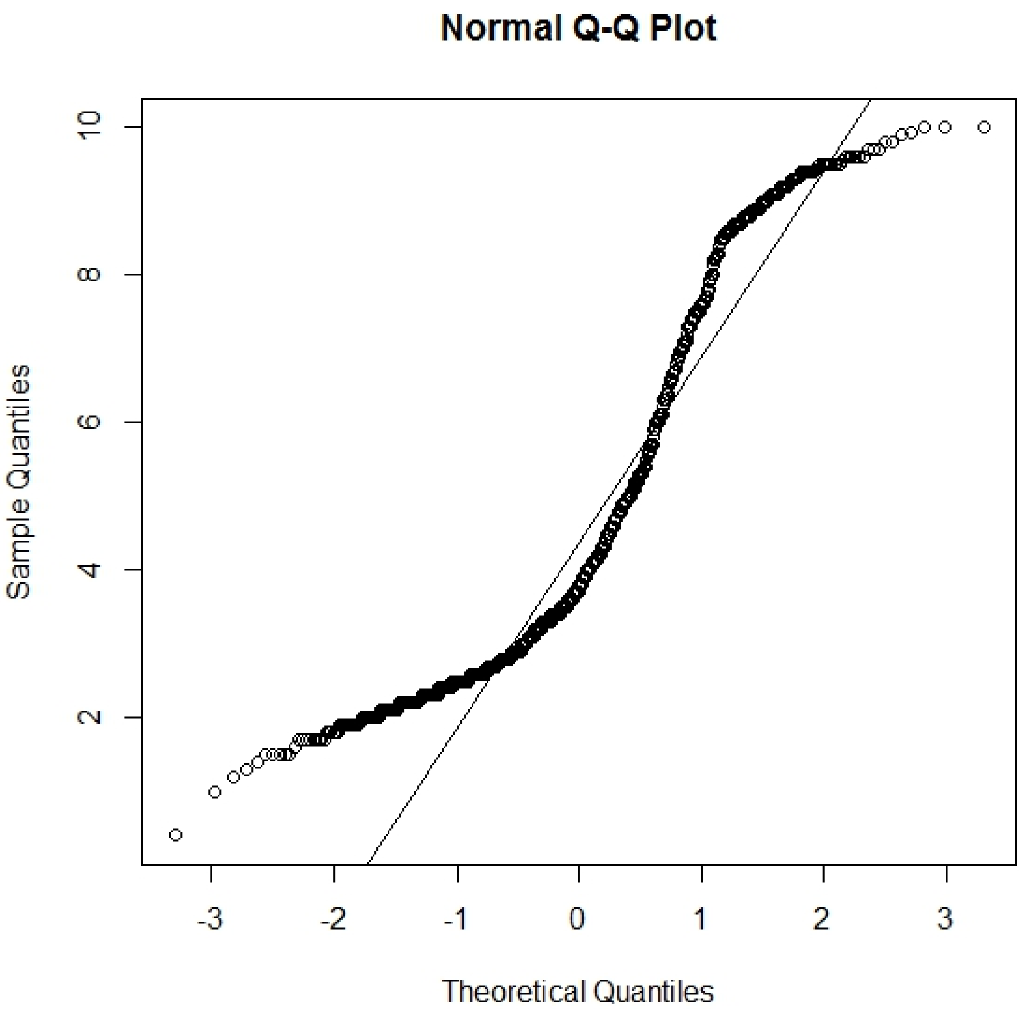

Figure 3: Kernel Distribution

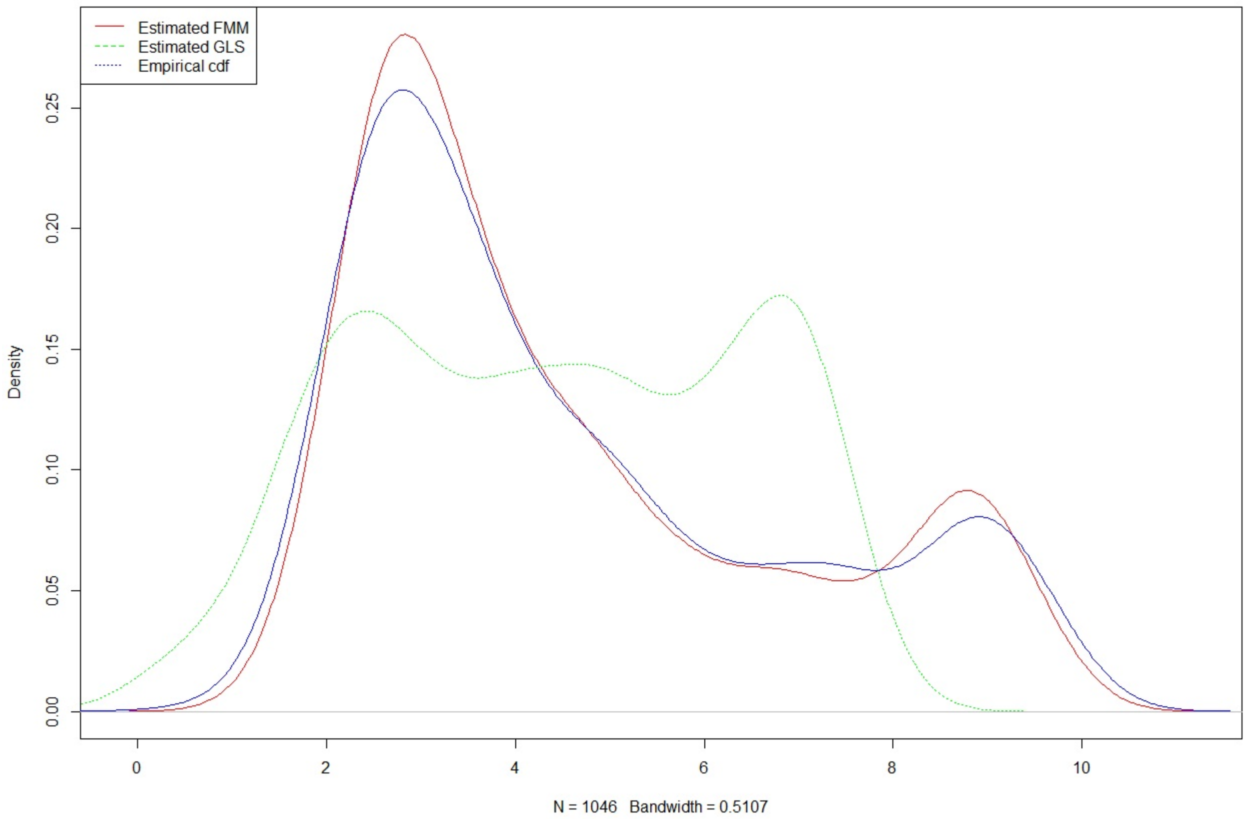

Figure 4: Components number: AIC BIC ICL criteria

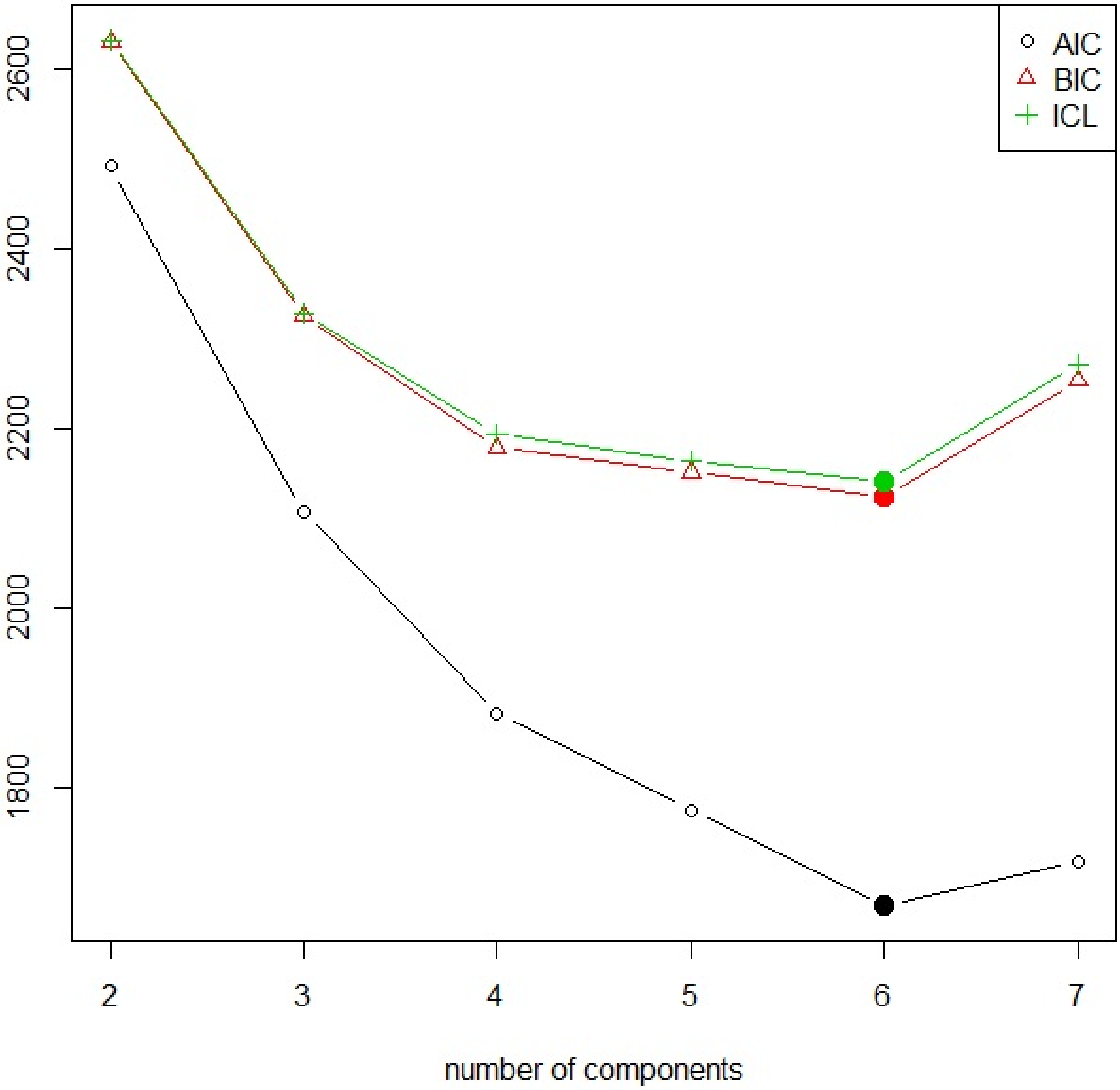

Figure 5: Estimated Cumulative Distribution Function